ICING
&
TURBULENCE

OVERVIEW:

IDENTIFY FORMATION, TYPES, AND INTENSITES OF TURBULENCE AND ICING AND THEIR AFFECT ON AIRCRAFT.

TURBULENCE is caused by

orupt, irregular movements of the air that create shar
uick updrafts and downdrafts. These up and downdraf
occur in combinations and move aircraft unexpectedly

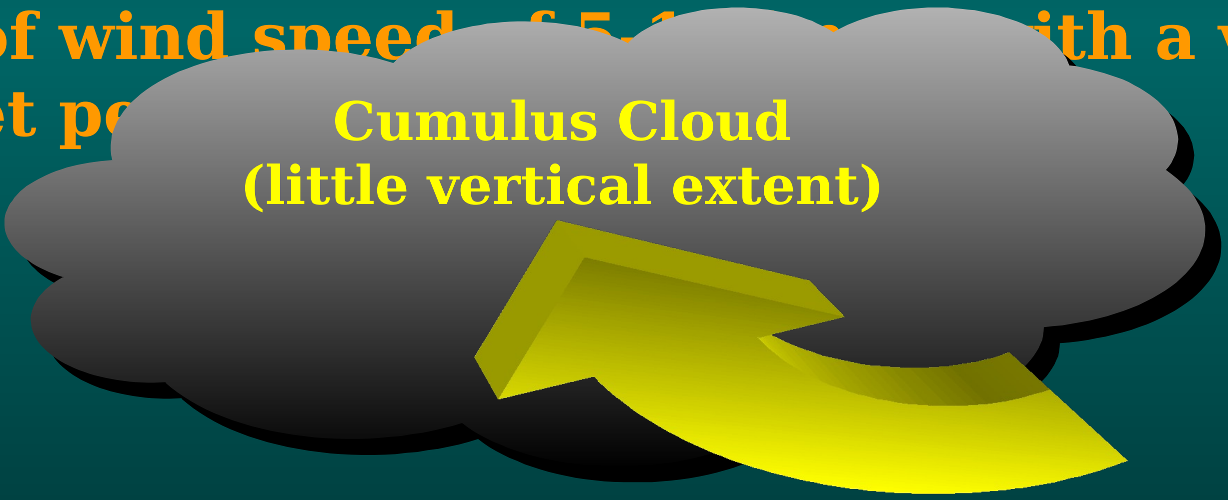
Two basic types of atmospheric conditions that cau
to occur are : Thermal conditions and Mechanical

TURBULENCE
LEVELS OF INTENSITY

Areas of consideration:

1. In and near Cumulus clouds.

1. LIGHT TURBULENCE – The aircraft experiences erratic changes in attitude and/or altitude, caused b variation of wind speed of 5-1 ith a vertica of 5-19 feet pe

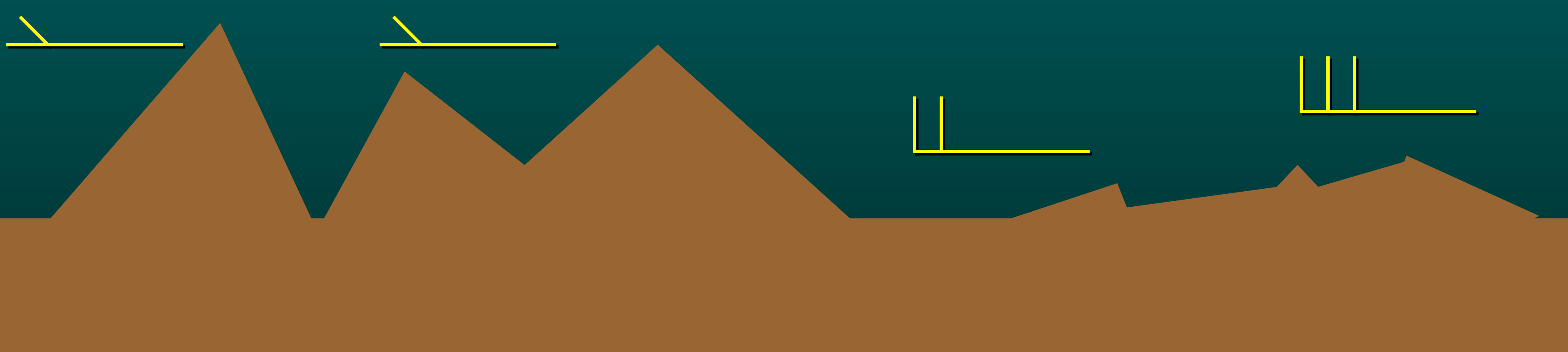


TURBULENCE
LEVELS OF INTENSITY

Areas of consideration:

2. At low altitudes in rough terrain when winds exce

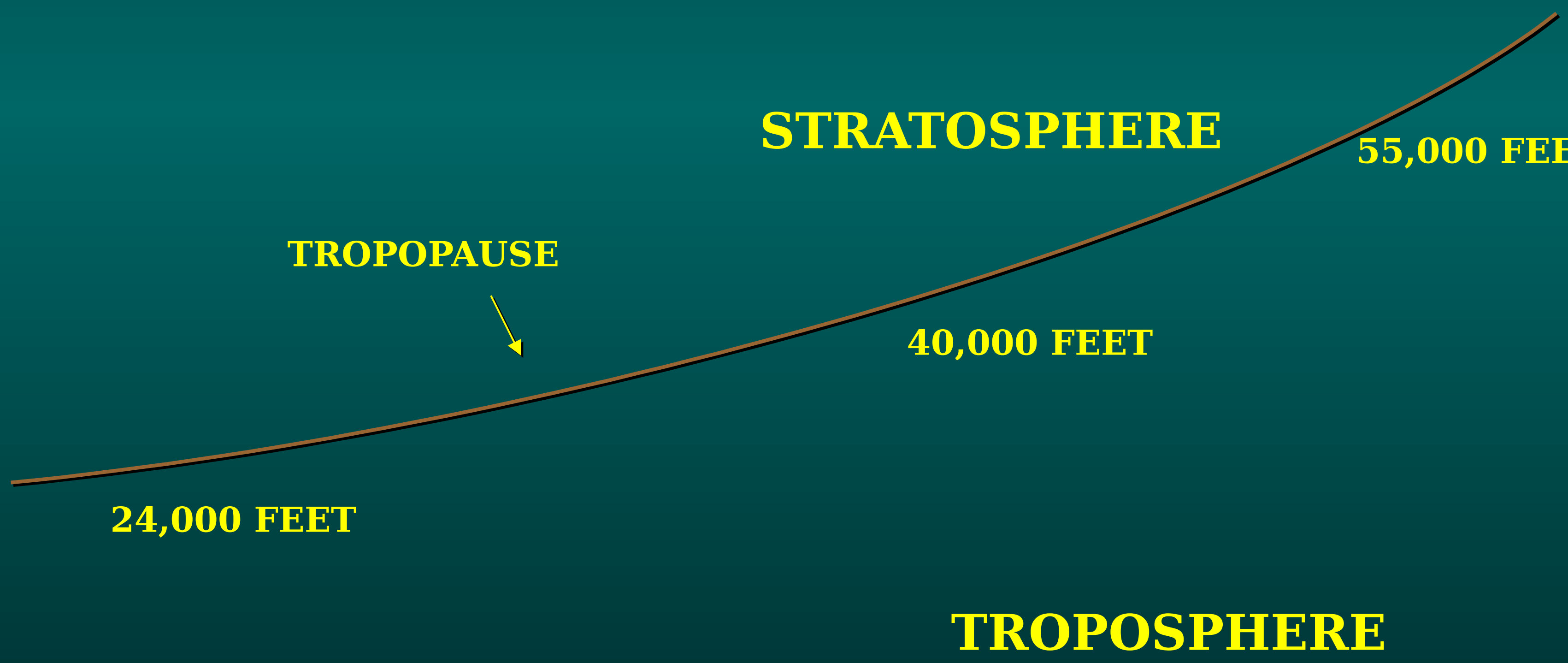
3. In mountainous areas, even with light winds.



TURBULENCE
LEVELS OF INTENSITY

Areas of consideration:

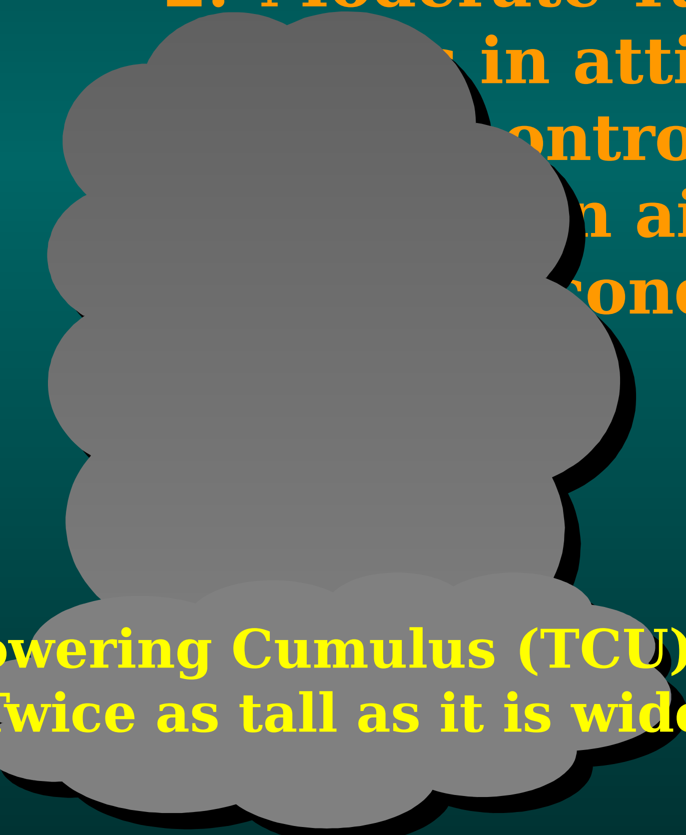
4. Near the tropopause -

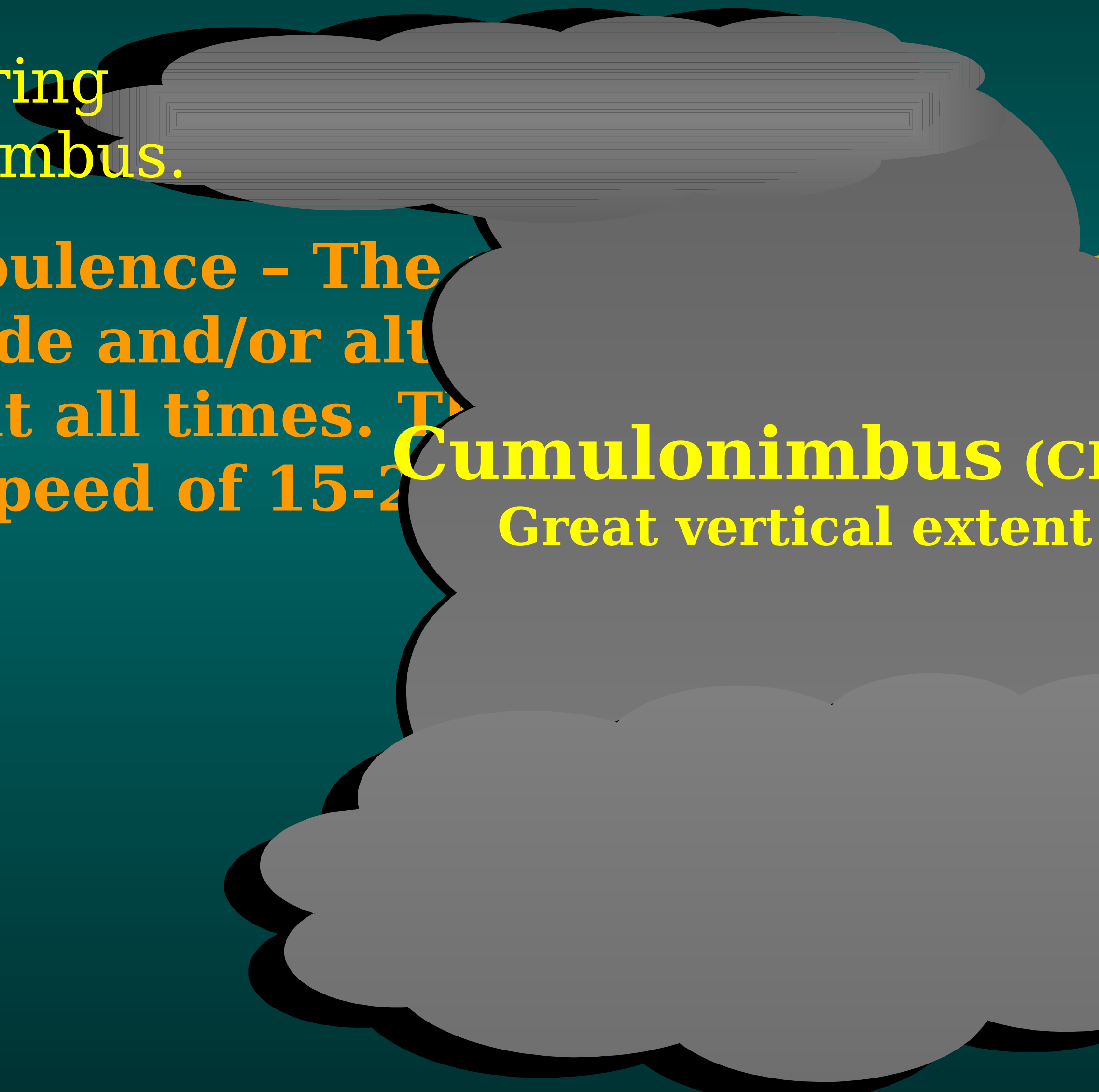


TURBULENCE
LEVELS OF INTENSITY

1. In and around Towering Cumulus and Cumulonimbus.

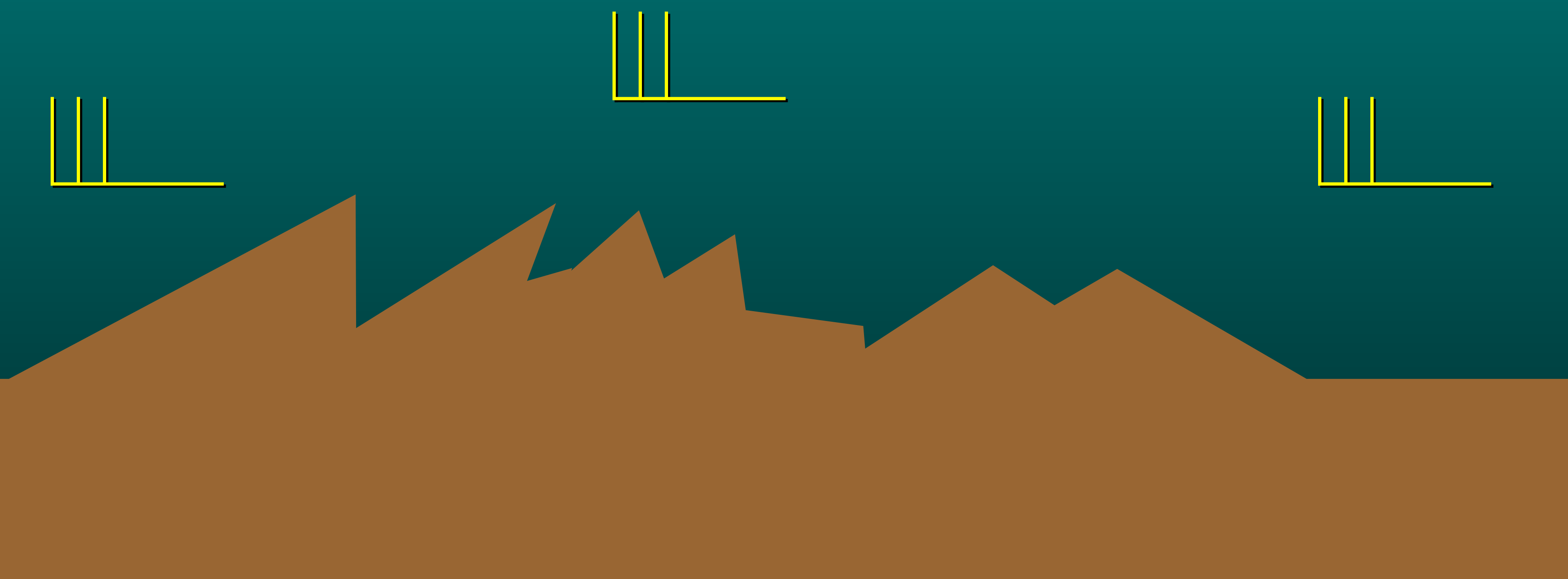
2. Moderate Turbulence – The ... in attitude and/or alt... ontrol at all times. T... n airspeed of 15-2... cond.





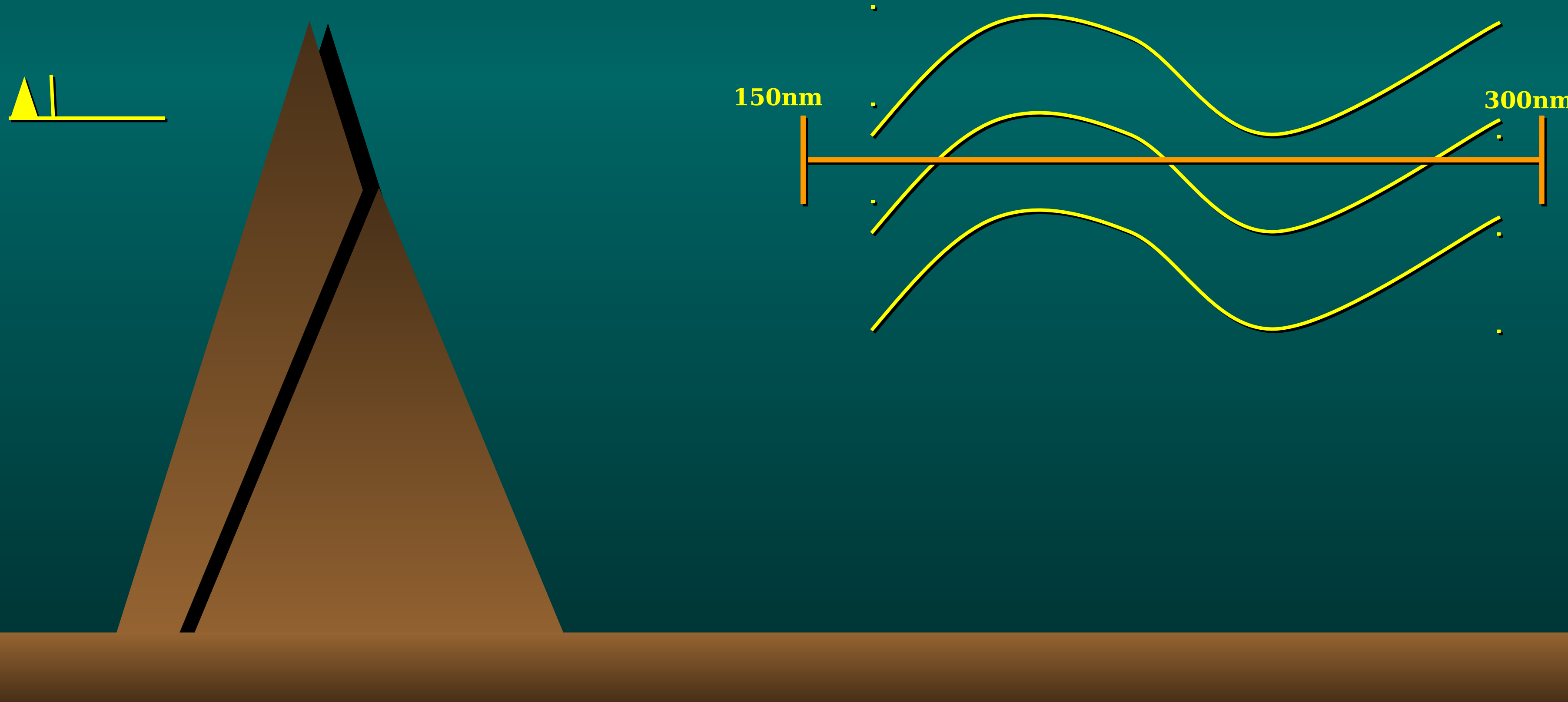
TURBULENCE
LEVELS OF INTENSITY

2. At low altitudes in rough terrain, when the surfa
exceed 25 knots.



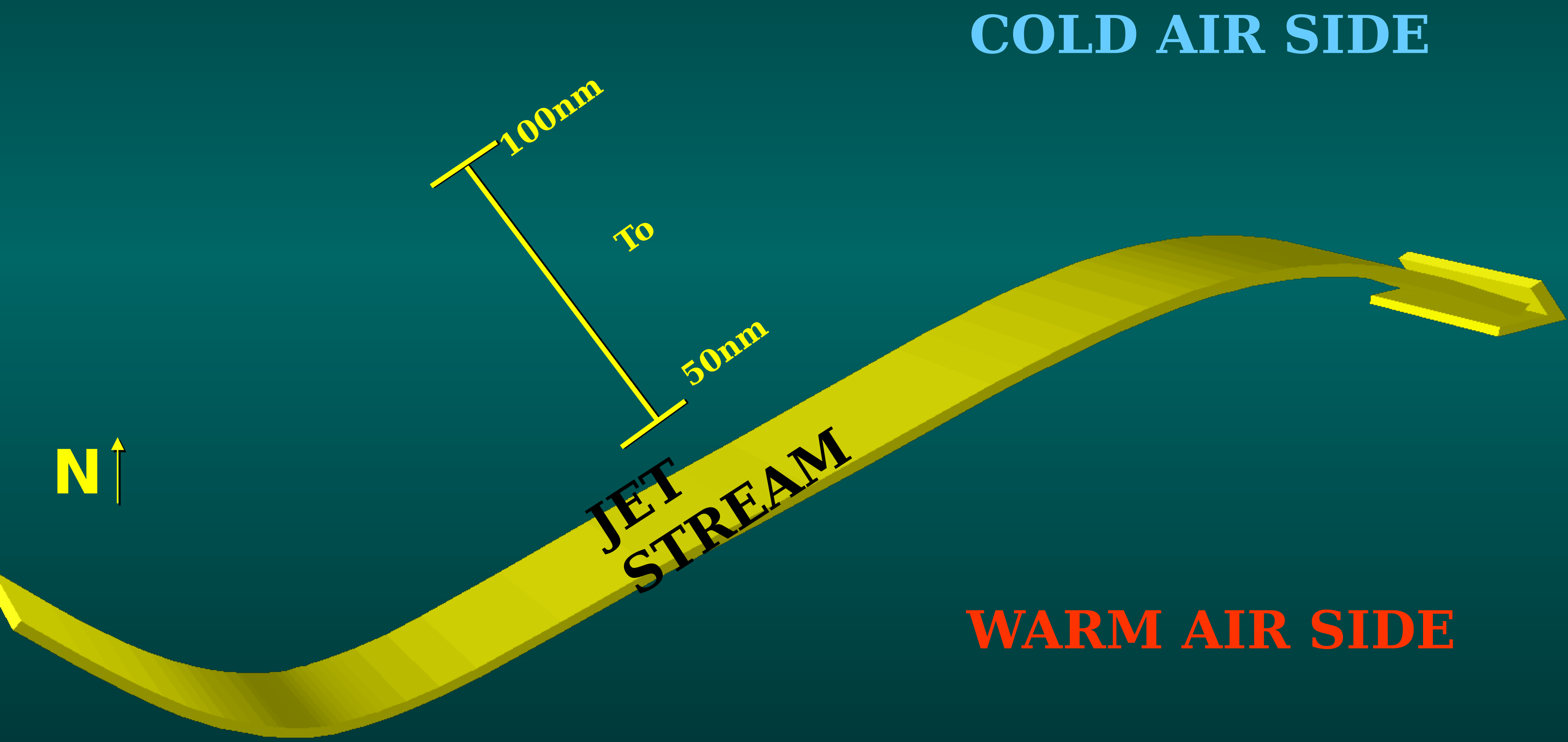
TURBULENCE
LEVELS OF INTENSITY

3. When wind components of 25 to over 50 knots exist near the ridge level, turbulence may be seen 150-300 miles o[n] the leeward side of the mountain.



TURBULENCE
LEVELS OF INTENSITY

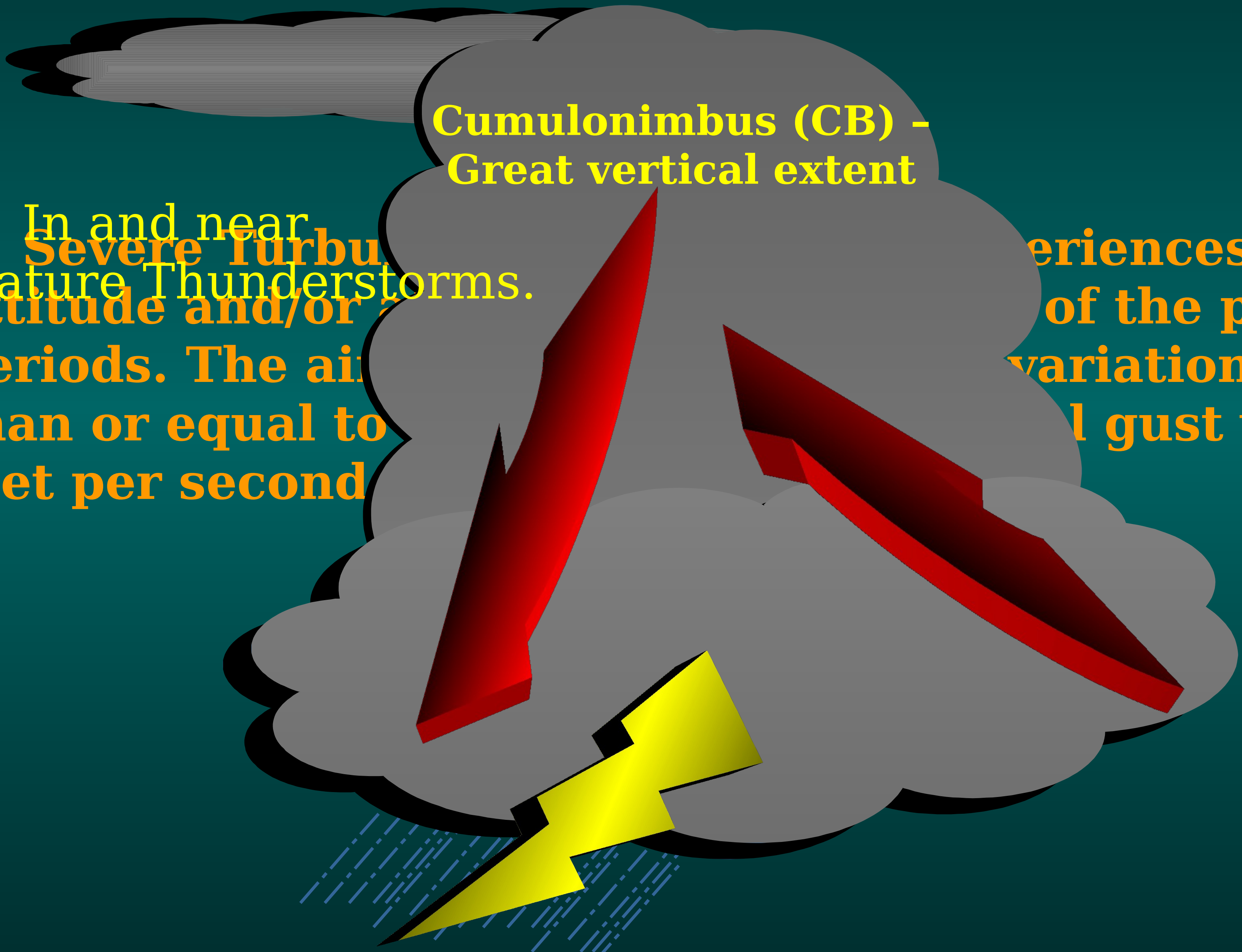
4. Near Jet Stream altitude, and about 50-100 mile
   cold-air side of the jet.



TURBULENCE
LEVELS OF INTENSITY

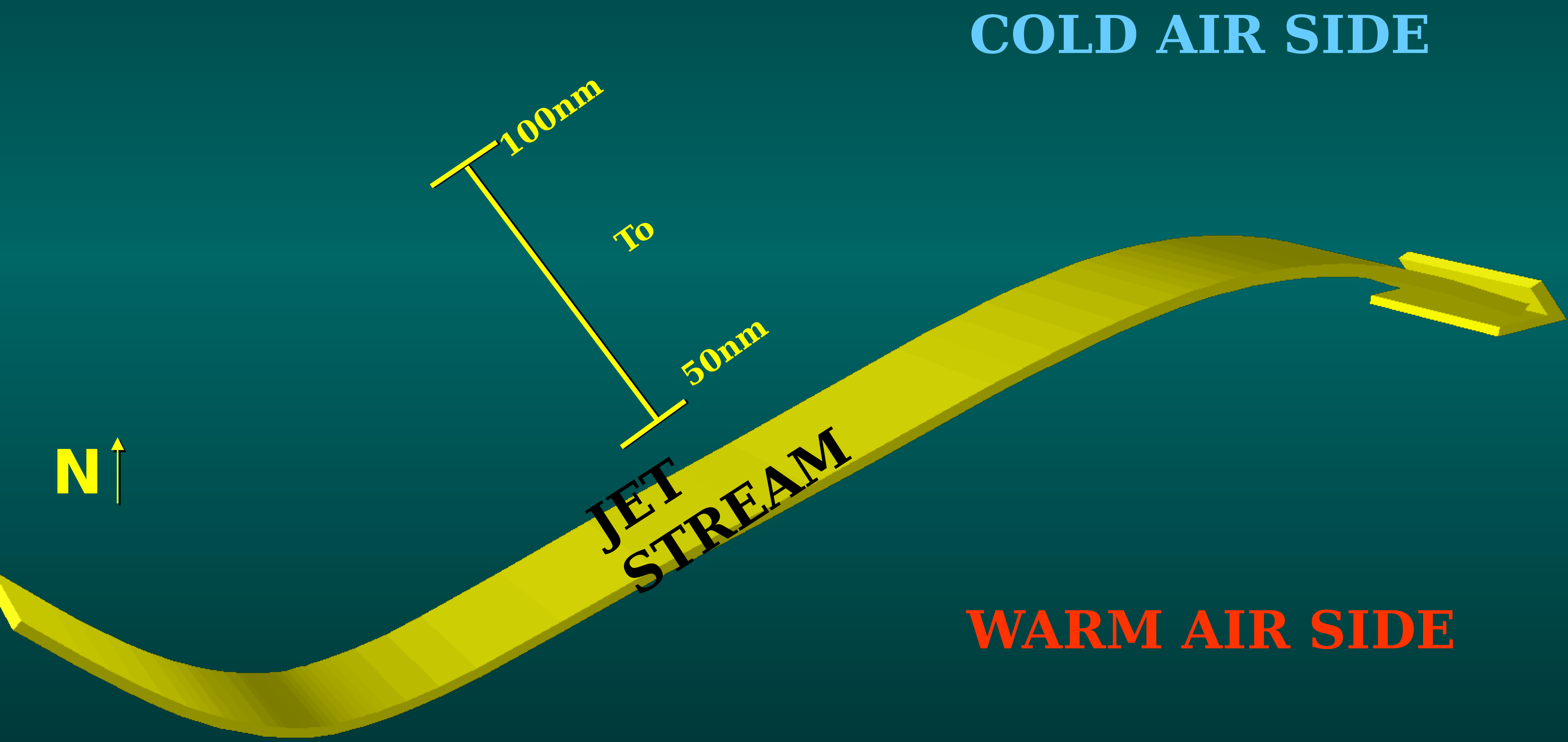
1. In and near mature Thunderstorms.

3. Severe Turbu… eriences abru… attitude and/or a… of the pilot's periods. The ai… variations is a… than or equal to … l gust veloci… feet per second



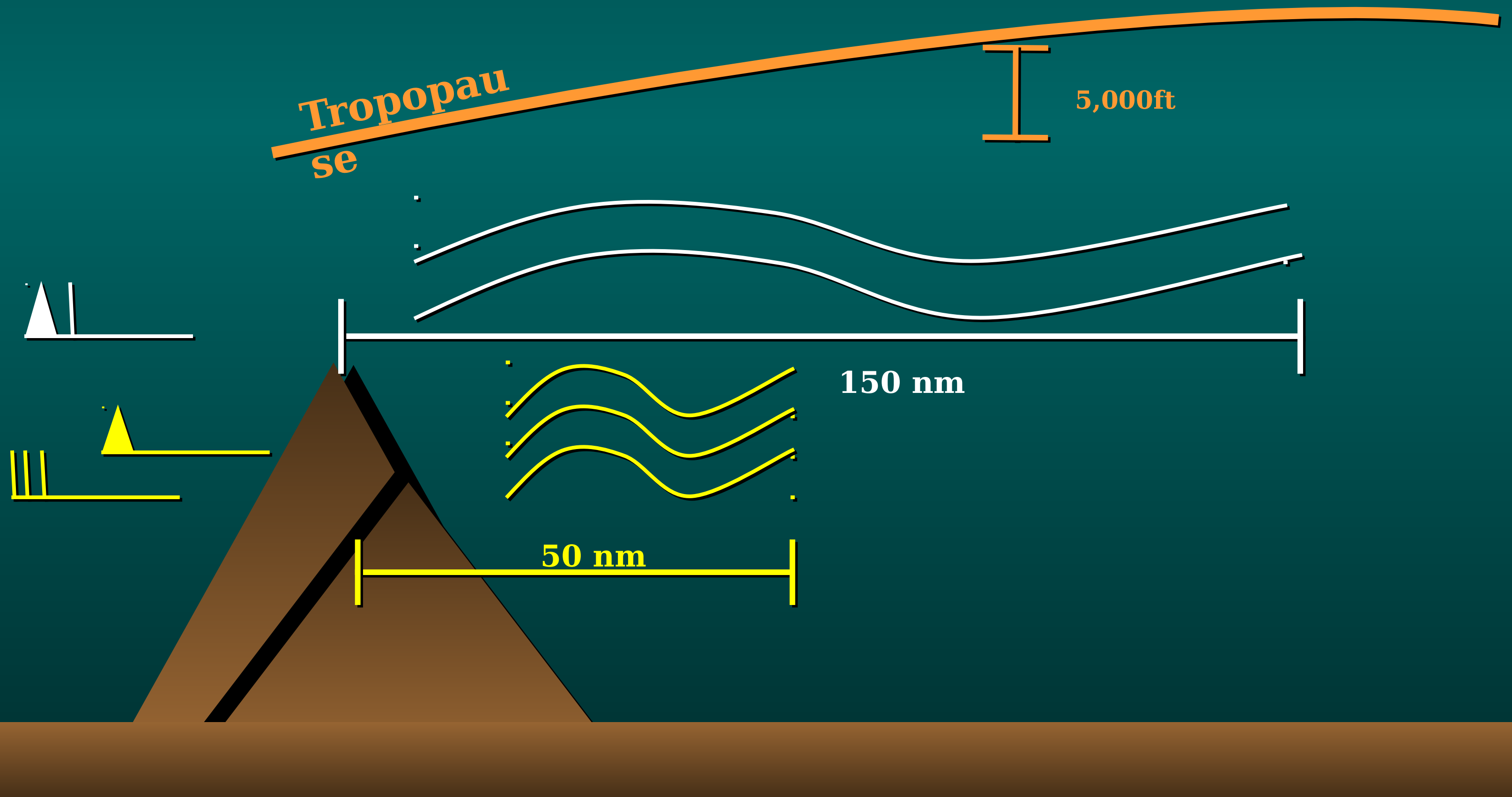
TURBULENCE
LEVELS OF INTENSITY

2. Near Jet Stream altitude, and about 50-100 mil
cold-air side of the jet core.



TURBULENCE
LEVELS OF INTENSITY

3. In mountain waves, 50 miles on leeward side, with
   knots.
4. Up to 150 miles , leeward side of mountain, and within 5,000 feet of the tropopause when a moun wave exists with winds in excess of 50 knots.



TURBULENCE
LEVELS OF INTENSITY

4. Extreme Turbulence – The aircraft is violently tos
Is practically impossible to control. Structural dama
Rapid fluctuations in airspeed are the same as Seve
(greater than or equal to 25 knots) and the vertical
Greater than or equal to 50 feet per second.

Though Extreme Turbulence is rarely encountered,
Found in the strongest forms of convection and win

The two most frequent locations are:

1. In mountain waves, in or near the Rot
2. In severe thunderstorms, especially in
   squall lines.

TURBULENCE

Thermal Turbulence:

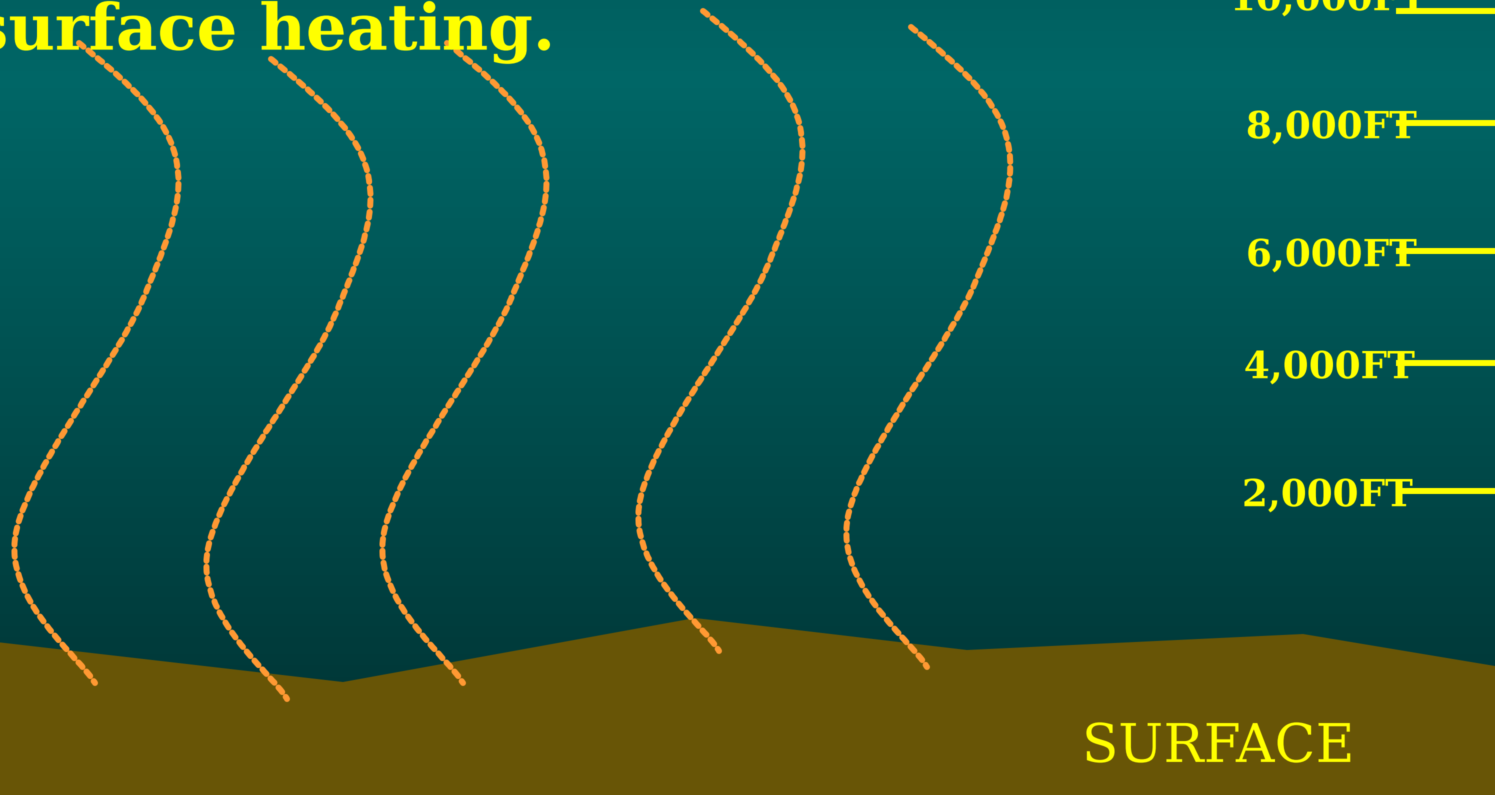
5. The strongest Thermal turbulence is found in and thunderstorms. Moderate or severe turbulence may b anywhere within the storm, including the clear air al edges. The highest probability is found in the storm 10,000 and 15,000 feet.

TURBULENCE
LEVELS OF INTENSITY

Thermal Turbulence:

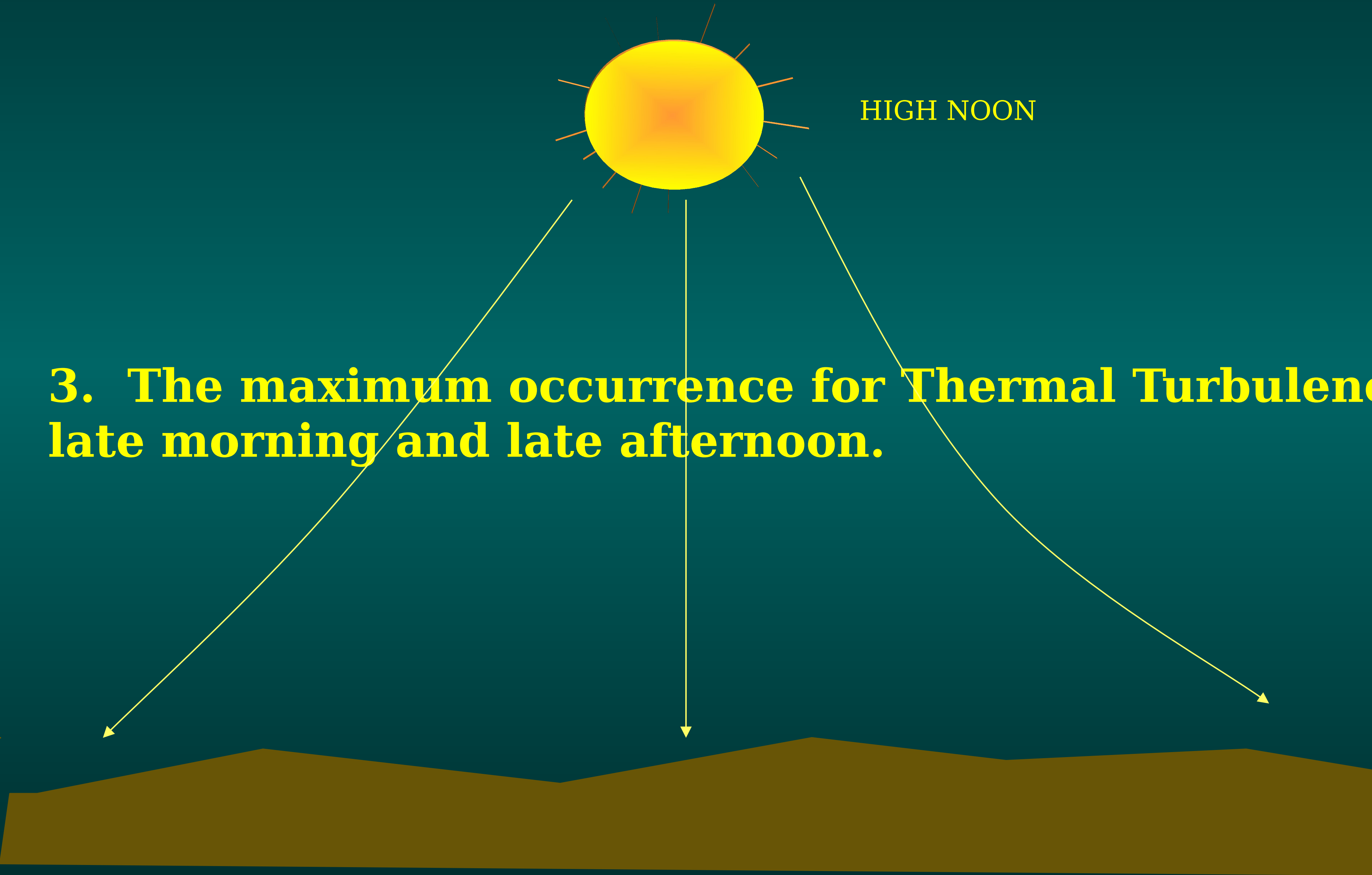
1. Normally confined to lower troposphere (SFC – 10,

2. Moderate turbulence may occur in hot, arid region
of intense surface heating.



TURBULENCE

Thermal Turbulence:

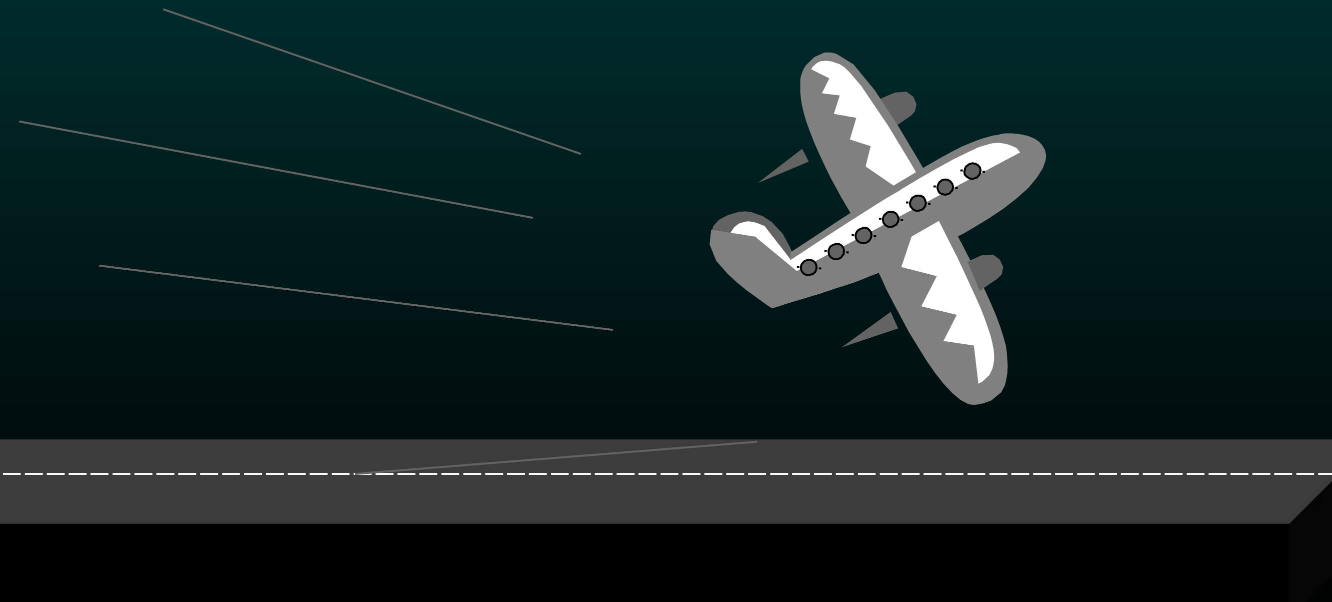


**3. The maximum occurrence for Thermal Turbulenc
late morning and late afternoon.**

TURBULENCE

Thermal Turbulence:

4. The impact on flight operations is greatest durin approach and departure and during low-level flight



TURBULENCE

Thermal Turbulence:

5. The strongest Thermal turbulence is found in and thunderstorms. Moderate or severe turbulence may b anywhere within the storm, including the clear air al edges. The highest probability is found in the storm 10,000 and 15,000 feet.

TURBULENCE

Mechanical Turbulence:

1. Most turbulence results from a combination of hor
Vertical wind shears.

2. Turbulence layers are usually 2,000 feet thick, 10-
Several times longer than wide.

3. Wind Shear turbulence results from strong horizo
gradients alone. It occurs when the pressure gradien
horizontal shear in either wind direction or speed.

4. Local terrain can magnify gradient winds to cause
near the surface. This creates eddy currents that can
flight operations hazardous.

TURBULENCE

Mechanical Turbulence:

5. Most turbulence resulting from upper frontal zone
Between 10,000 – 30,000 feet.

6. The jet stream causes most turbulence in the uppe
and lower stratosphere, usually occurring in patches
with the strongest Turbulence found on the cold-air s
Jet Stream.

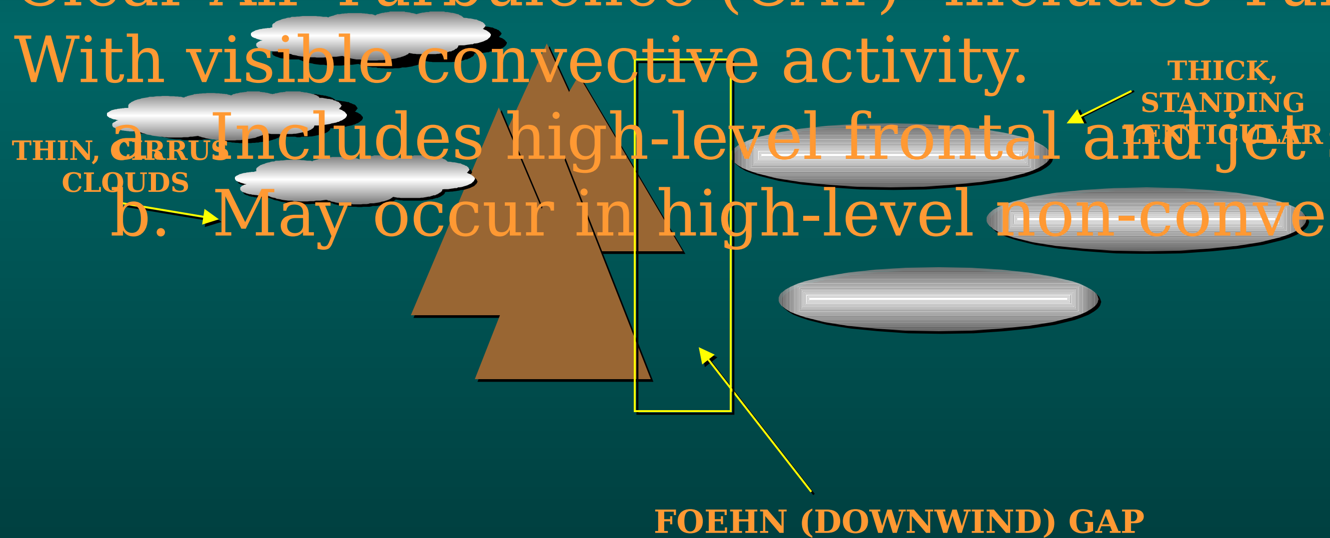
7. Fronts may produce moderate or greater turbulenc
    1. Turbulence intensity will depend on the strengt
    2. Over rough terrain, fronts produce moderate or
       level Turbulence.
    3. Over flat terrain, fronts moving at 30kts also pr
       moderate or greater low-level turbulence.
    4. Updrafts may reach up to 1,000 feet per minute
       zone at low-levels just ahead of a front.

TURBULENCE

Mechanical Turbulence:

8. MOUNTAIN WAVE - The most severe type of terra Turbulence. It occurs in clear air and in a stationary of a predominant mountain range. It is caused by the disturbance of the wind by the mountain range.

9. Clear Air Turbulence (CAT)- includes Turbulence not a With visible convective activity.
   a. Includes high-level frontal and jet stream Turbul
   b. May occur in high-level non-convective clouds.



TURBULENCE

Mechanical Turbulence:

9. Clear Air Turbulence (CAT)- includes Turbulence not as
   With visible convective activity.
   a. Includes high-level frontal and jet stream Turbule
   b. May occur in high-level non-convective clouds.

AIRCRAFT ICING

STRUCTURAL ICING INTERFERES WITH AIRCRAFT
ONTROL BY INCREASING DRAG AND WEIGHT WHIL
DECREASING LIFT.

INE-SYSTEMS ICING REDUCES THE EFFECTIVE POW
OF AIRCRAFT ENGINES.

ICING
FACTS

ICING MAY OCCUR DURING ANY SEASON OF THE YEAR

More frequent during winter season

- **Aircraft Icing generally occurs between Freezing Le (rare at temperatures below -30ºC).**

- **The frequency of Icing decreases rapidly with decre temperatures.**

- **Icing is usually restricted to lower 30,000 feet of atr**

ICING
Types

AIRCRAFT STRUCTURAL ICING CONSISTS OF 3 TYP

1. **CLEAR**
2. **RIME**
3. **FROST**

- **MIXTURES OF CLEAR AND RIME ARE COMMON (MIXED)**

- **THE TYPE OF ICING THAT OCCURS IS DEPENDANT UPON TH TEMPERATURE AND WATER DROPLET SIZE**

ICING Types

CLEAR ICING – GLOSSY, CLEAR OR TRANSLUCENT ICE FO
BY RELATIVELY SLOW FREEZING OF LARG
SUPERCOOLED DROPLETS.

*** POTENTIALLY THE MOST DANGEROUS TYPE OF ICING .**

- **THE DROPLETS SPREAD OUT OVER THE AIRFRAME SURF**
  BEFORE COMPLETELY FREEZING.

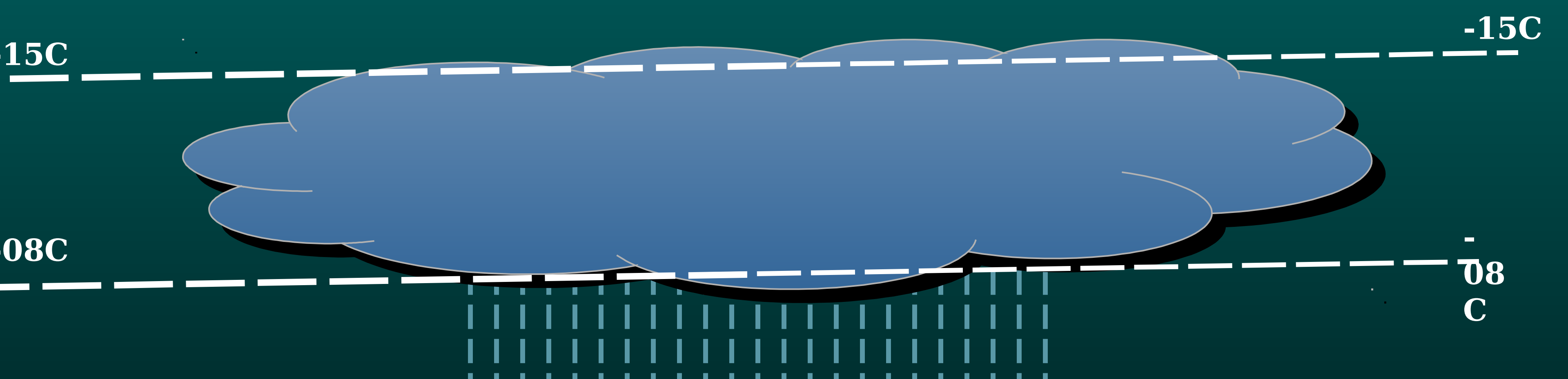
*** SINCE IT IS TRANSPARENT, THE ICING MAY GO UNDETEC**

ICING Types

CLEAR ICING

Adheres firmly to the exposed surfaces, and is muc
difficult to remove with deicing equipment than ri

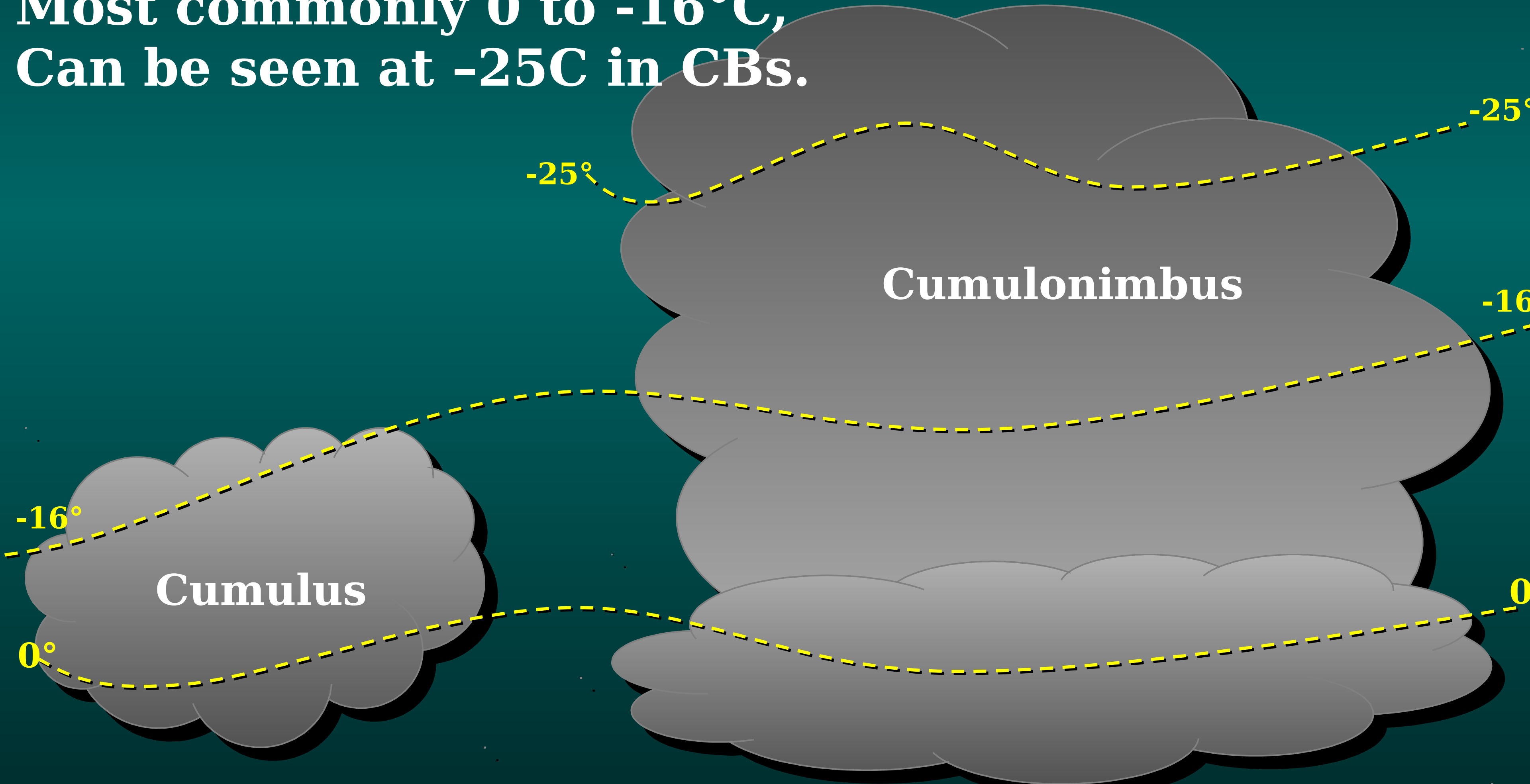
Occurs most frequently within Stratus clouds at t
between –8ºC and –15ºC.



ICING
Types

CLEAR ICING

Forms in cumulus clouds,
Most commonly 0 to -16°C,
Can be seen at –25C in CBs.

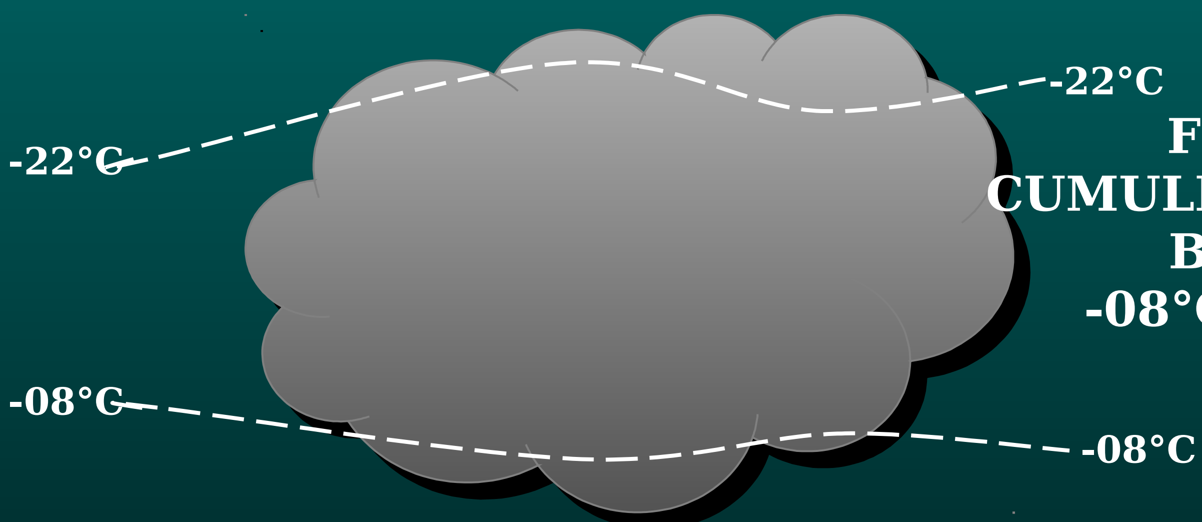


ICING
Types

<u>RIME ICING</u> –

A MILKY, OPAQUE, AND GRANULAR DEPOSIT WITH A ROUGH SURFACE

IT FORMS BY THE RAPID FREEZING OF SMALL SUPERCOO WATER DROPLETS. THIS INSTANEOUS FREEZING TRAPS A LARGE AMOUNT OF AIR, GIVING THE ICE ITS OPAQUENES MAKING IT VERY BRITTLE.



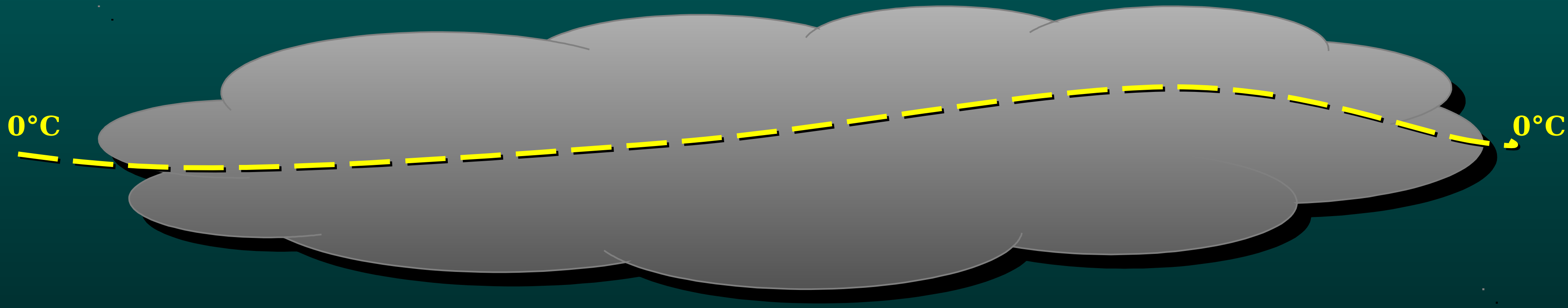
FORMS IN CUMULIFORM CLOUD BETWEEN -08°C AND -22°C

ICING Types

RIME ICING –

A MILKY, OPAQUE, AND GRANULAR DEPOSIT WITH A ROUGH SURFACE

CAN FORM IN STRATIFORM CLOUDS FROM 0°C TO –22°C, BUT IT OCCURS MOST FREQUENTLY -8°C TO -22°C



ICING
Types

<u>FROST ICING</u> –

FROST IS A LIGHT, FEATHERY DEPOSIT OF ICE CRYSTALS THAT FORM WHEN WATER VAPOR CONTACTS A SUBFREEZING SURFACE.

FROST CAN OCCUR ON AN AIRCRAFT IN FLIGHT, ON THE GROUND, AND ON THE UPPER SURFACES OF PARKED AIRCRAFT DURING A CLEAR NIGHT WITH SUBFREEZING TEMPERATURES.

IT ALSO AFFECTS THE AIRCRAFT'S LIFT-TO-DRAG RATIO AND CAN BE HAZARDOUS DURING TAKE-OF

ICING
Types

<u>MIXED ICING</u> –

A COMBINATION OF RIME AND CLEAR ICING. IT IS FORMED WHEN WATER DROPLETS VARY IN SIZE OR WHEN LIQUID DROPLETS ARE COMBINED WITH SNOW OR ICE PARTICLES.

THE ICE PARTICLES BECOME EMBEDDED IN THE CLEAR ICING , BUILDING A VERY ROUGH APPEARA THAT CAN FORM RAPIDLY ON THE AIRFRAME.

- **MOST COMMON AT TEMPERATURES -08°C TO -15**
- **SIMILAR FORMATION TO RIME AND CLEAR ICIN**

ICING

Intensities

Trace - Icing first becomes perceptible as trace icing. The
is slightly greater than the sublimation rate. Trace icing i
hazardous to operations unless it persists for longer than

Light - Icing condition persists for over 1-hour. Accumulation
begins to create a problem for the aircraft. Occasional us
anti-icing equipment removes and/or prevents accumulat

Moderate - The rate of accumulation causes even short encoun
icing to be potentially hazardous. The use of deicing/
equipment is necessary.

Severe - The rate of accumulation is so strong that deicing/ant
fails to reduce or control the hazard. Immediate diversio

ICING VARIABLES

1. AIRSPEED –

The rate of ice formation increases with the speed of the aircraf
However, at very high speeds, friction creates enough heat on th
Aircraft to melt structural ice. Icing is seldom a problem at air
Of 575 knots.
Helicopter rotor speeds of 570 to 575 knots preclude ice buildu
Portion of the main rotor blades. The chance of ice buildup on
However, increases inward toward the rotor disk.

2. AIRCRAFT SIZE AND SHAPE –

The rate of ice formation will vary with size, shape and smoothn
Surfaces and airfoils. Ice accumulates faster on larger non-stre
With rough surface features than it does on thin, smooth highly
Aircraft. However, once ice has formed, the rate of ice formatio
Since the accumulated ice presents a larger surface area upon w
Can collect and freeze.

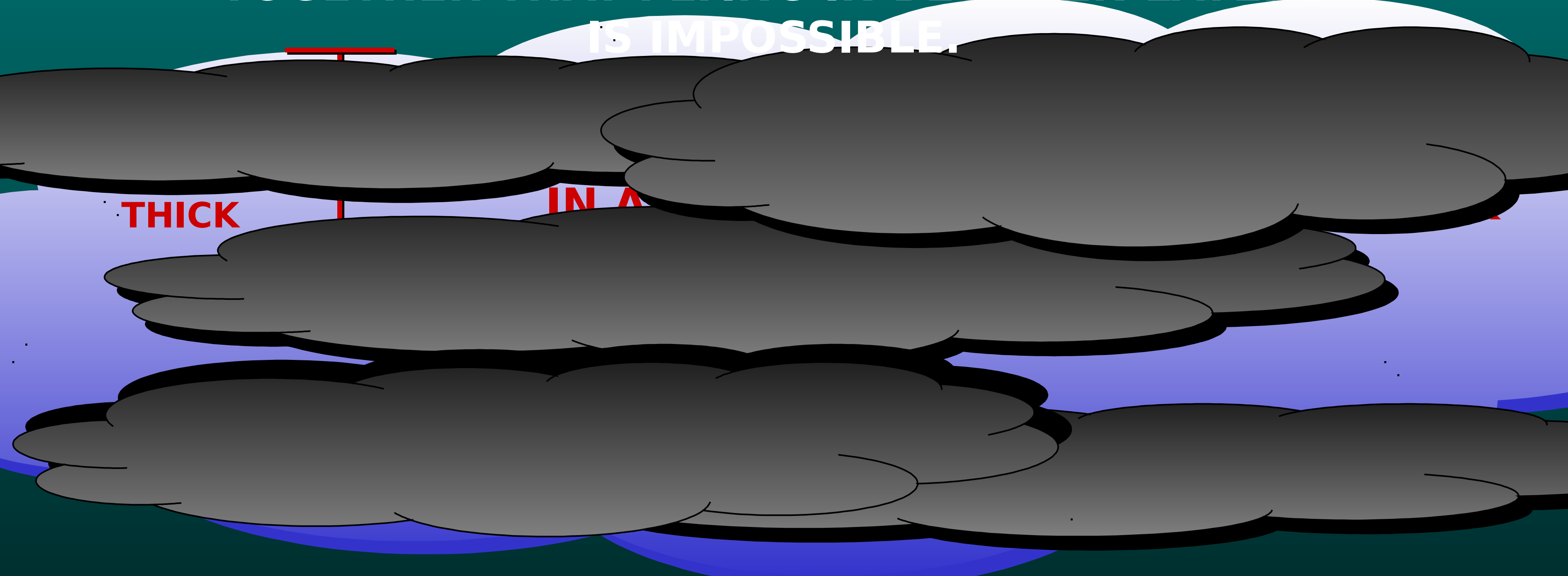
METEOROLOGICAL CONSIDERATIONS

CLOUDS

STRATIFORM CLOUDS

- POTENTIAL CONTINUOUS ICING CONDITIONS (RIME & MIXED)
- INTENSITIES IN-CLOUD RANGE FROM LIGHT TO MODERATE

MULTIPLE LAYERS OF CLOUDS MAY BE SO CLOSE TOGETHER THAT FLYING IN BETWEEN LAYERS IS IMPOSSIBLE.



?